IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	Docket No.: **TI-36792**
Jie Liang	Art Unit: **2611**
Serial No.: **10/724,376**	Examiner: **GHULAMALI, Qutbuddin**
Filed: **11/28/2003**	Conf. No.: **9657**

For: **LOW POWER PACKET DETECTOR FOR LOW POWER WLAN DEVICES**

DECLARATION TRAVERSING REJECTIONS OR OBJECTIONS (37 C.F.R. § 1.132)

Mail Stop Non-Fee Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22131-1450

Dear Sir:

1. This declaration is to establish conception of the invention in this application in the United States at a date prior to July 28, 2003, which is the first effective date of the cited United States patent publication to Keaney et al. US Publication 2006/0193277 and United States patent to Lyons et al. U.S. Patent 6,922,549, which were cited by the Examiner.

2. The individual making this declaration is Steven A. Shaw, practitioner in charge of the docket for which the invention belongs. Jie Liang, the inventor is no longer employed by Texas Instruments, Incorporated.

3. To establish the date of conception of the invention of this application, a true copy of a portion of the disclosure form signed by inventor and submitted to the Patent

Department of Texas Instruments Incorporated and assigned docket no. TI-36792 is submitted as evidence (Exhibit A). This disclosure was made prior to the July 28, 2003.

4. This declaration is submitted prior to final rejection.

6. As a person signing below:

I hereby declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

Steven A. Shaw
Attorney for Assignee Texas Instruments
Reg. No.: 39,368
Date: April 25, 2007

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TI INVENTION / INNOVATION DISCLOSURE

TI-36792

SEND COMPLETED FORM TO:

TI CORPORATE PATENTS
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If you are employed by a TI subsidiary company, send this form to your site coordinator.

To prepare your invention disclosure, follow the step-by-step directions on the form that follows. Type or print answers to the questions in the spaces provided.

PLEASE PROVIDE ANSWERS TO ALL OF THE QUESTIONS OTHERWISE THERE COULD BE DELAYS IN PROCESSING

If you already have an engineering spec, please send it with your invention disclosure. Computer documentation and drawings, marketing foils, notebook entries, paper manuscripts, articles, and any other material that you already have can be copied or sent electronically.

Exhibit A

PATENT DISCLOSURE FORM

DOCKET NO. TI-(to be filled in by Patent Activity)

IF ELECTRONICALLY TRANSMITTED, PROCESSING OF YOUR DISCLOSURE CANNOT BE COMPLETED WITHOUT A FOLLOW-UP COPY SIGNED AND DATED BY ALL INVENTORS AND AT LEAST ONE WITNESS.

1. Please suggest a descriptive title for your invention:

   Low Power Design Method for WLAN Channel Estimation and Pilot Processing

2. This invention supports strategy: (check 1 or more)

☐	DLP	DSPS	
☐	Materials	☒	Wireless
☐	Fab/Processes	☐	Video
☐	Assembly/Test/Packaging	☐	Set Top
☐	Other	☐	Application Specific
		☐	Remote/Access/Networking
		☐	Emerging Markets
		☐	Mixed Signal & Logic
		☐	Mass Storage
		☐	Other

3. What is the problem solved by your invention?

   Power consumption has become a major performance factor for the WLAN chipset. Channel estimation and pilot processing is the most MIPS intensive task in 802.11a/g baseband. This invention described an architecture to lower the design of channel estiamtion and pilot processing module.

4. What is your solution to the problem?

   By analyzing the MIPS requirement of the channel esitmation and pilot processing algorithms, it was found that the typical channel estimation algorithm costs much more MIPS than pilot tracking. This invention desribes an architecture to take advantage of this fact.

5. When was your solution first conceptually or mentally complete?

Date: 05/2003

6. What is the first tangible evidence of such completion?

Date: 07/2003

7. What is different about your solution, compared with other solutions to the same problem?

Most of the WLAN chipset manage power at the top module (TX, RX, IDLE, SLEEP, etc). They also tend to bundle the channel estimation and pilot tracking module together in terms of power managemnet. This architecture separate the two modules, and manage their clock tree using RX status.

8. What are the advantages of your solution?

Lower Power.

9. What TI products, processes, projects or operations currently implement your invention?

In discussions with WLAN BU regarding implementation.

10. What is the date of the first implementation?

Date: N/A

11. What record exists to prove this date?

N/A

12. Is there any future implementation planned?

Yes ☐ No ☒

If so, please furnish the TI PART No. or project name

13. Has the invention been published or disclosed to anyone outside of TI?

Yes ☐ No ☒

When?

If planned - when? (Catalog, advertising, data book, application note, conference paper, magazine article, TI TJ, proposal document.)

Was there a nondisclosure agreement (NDA)?

Yes ☐ No ☐

14. Has a TI product incorporating the invention been publicly introduced, quoted, sampled or shipped?

Yes ☐ No ☒

When? If planned--when?

15. Was the invention conceived or first implemented in the performance of a government contract or subcontract?

Yes ☐ No ☒

Contract #:

THE INVENTION DESCRIBED BY THIS DISCLOSURE IS SUBMITTED PURSUANT TO MY EMPLOYMENT AGREEMENT WITH TEXAS INSTRUMENTS INCORPORATED OR A TI SUBSIDIARY (SPECIFY):

Has this disclosure been previously sent to the Patent Department electronically (unsigned)?

Yes ☒ No ☐

PLEASE PRINT ALL INVENTOR INFORMATION.

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Inventor 1's Signature:	_____
Date: 07/15/2003	
Mail Station:	

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* *

This invention disclosure with any attachments was read and understood by me on

Manish [signature] 07/15/2003

Witness 1: Date

This invention disclosure with any attachments was read and understood by me on

Witness 2: Date

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JUL 18 2003
PATENT DEPT

(grow)^{TI}

Methods for Reducing Channel Estimation and Pilot Processing Power Consumption for 802.11a Baseband

Jie Liang
Communications Lab
DSPS R&D
Texas Instruments

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JUL 1 8 2003
PATENT DEPT

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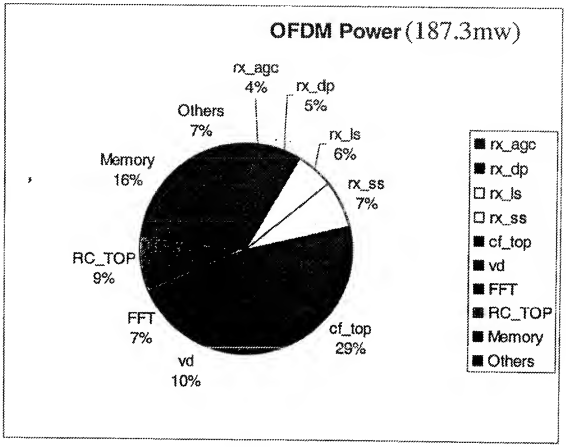
(grow) TI 1130 OFDM Receive Module: Power



Almost 30% of OFDM baseband power is in channel estimation and pilot processing!

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Current Design of Channel Estimation/Pilot Tracking Module

- A bank of 13 complex MAC units are used for both channel estimation and pilot tracking
  - Majority of the CRFO module power was consumed by these MAC units
  - Both channel estimation (during long sequence processing) and pilot processing during data symbols share the same module

- The duty cycle of the two functions are very different:
  - Channel estimation needs to be done only once for very packet:
    - ✓ complete in about 4us
  - Pilot processing is active throughout the whole data portion

A lot of power can be saved if a simpler module can be used exclusively for pilot processing, and shut down channel estimation module for data symbols.

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(grow)^{TI} MIPS Requirement for Channel Estimation

- Algorithm:

$$y=Ax$$

A: 52x52 complex matrix, LS inverse matrix for a given channel rank

x: 52x1 complex vector, raw channel gain

y: 52x1, smoothed channel gain for each tone

- MIPS Estimation:
  - A matrix/vector multiplication is involved:
    - ✓ 52x52 complex matrices, 52x1 vector
    - ✓ complete in about 4us
    - ✓ Total MIPS: *2.5 GOPS* (assume 4 real MAC = 1 complex MAC)

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MIPS Requirement for Pilot Processing (1)

- Algorithm:

  Step 1: Linear regression on each of 4 pilots (phase unwrap)
  Step 2: Weighted LS solution for intercept at current symbol (4x2 matrix)
  Step 3: Linear regression on the phase offset (intercept) across symbols
  Step 4: Cal. Correction factor for each tone (48 data tones)

- MIPS Estimation:

  – Linear Regression: new results can be obtained based on running sum (only add new updates)

$$y = b \cdot x + a, then$$

$$b = \frac{\frac{1}{n}\left(\sum_{i=1}^{N} xi \cdot yi\right) - \bar{x} \cdot \bar{y}}{\frac{1}{n}\sum_{i=1}^{N} xi^2 - \bar{x}^2}, a = \bar{y} - b \cdot \bar{x}$$

Note: all are real arithmetic

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MIPS Requirement for Pilot Processing

- MIPS Estimation:
  - Weighted LS solution:

$$y = (z^t W z)^{-1} z^t W x, where$$

$$W \in R4x4, z \in R4x2, x \in R4x1,$$

$$y \in R2x1$$

  - Total of 5 linear regression (8 MAC/LR), and 1 LS matrix inversion (56MAC), plus compensation factors (48MAC)
  - Total MIPS: *36 MIPS*

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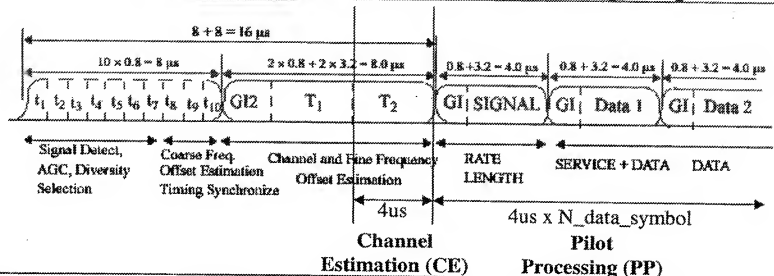
Channel Processing Duty Cycle



The duty cycle for channel estimation is brief:

- -1024 bytes packets
- - 24mbps (16QAM,1/2 code rate)
- - Data symbols: 86
- - Duty cycle (CE/PP): 1.2%

⇒The total CE+PP power is dominated by PP module if proper power management is used

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Low Power CRFO Module Design

- Pilot processing takes 1.4% of MIPS compared with channel estimation
- A dedicated pilot processing module may consume 10% of power compared with the current shared design (taking into account of control and memory access overhead)
- The dedicated module may use subset of the MAC units used for channel estimation
- **50mw power saving with no performance degradation**

Current	Proposed	Savings
56mw	*6mw*	*50mw*

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